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BIAS CORRECTION FOR RCM PREDICTIONS OF PRECIPITATION IN VARTU RIVER BASIN OF GUJARAT, INDIA

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ABSTRACT

The Global climate models are able to develop the climate change projections for the future using greenhouse gas emissions. But they have the limitations of focusing local climate for the resolution of the processes caused due to topography and land use of the study area. So, to avoid such limitations the regional climate models (RCMs) have developed. The Climate data like precipitation of A1B scenario for the Vartu river basin in Gujarat was utilized in this study. Bias correction was performed to ensure that important statistics (coefficient of variation and mean) of the downscaled output matched the corresponding statistics of the observed data. Predictions show that annual rainfall in the Vartu river basin may decrease by about 7-8 % from the present day annual average value according to the A1B scenario from the present day average values in the 2046-2064 and 2081-2100 scenarios respectively.

KEYWORDS: Bias Correction, RCM Predictions, Vartu River Basin, Thematic Mapping, Remote Sensing and GIS

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Original Article

INTRODUCTION

Climate change is known to create many challenges and controversies worldwide while projecting the impacts of climate change at regional scale allows communities to be better management and planning of natural aspects for the future. Impacts of climate change and climate variability on the water resources are likely to affect irrigated agriculture, installed power capacity, environmental flows in the dry season and higher flows during the wet season, thereby causing severe droughts and flood like situations in affected areas. India accounts for about 17.5 % of the world's population and roughly 4 percent of the total available fresh water resources among world water resources. The increase in evapotranspiration due to increase in temperature from plants and reduced soil moisture may increase the degradation of land and wastage of land for agriculture. Above mentioned aspects coupled to the scenario shows the water utilization rate in India is 59 percent, much ahead of the 40 percent standard, clearly pointing the need of better water management practices in the country to increase the water quantity and safety for proper economic development and human resources [3].

Regional Circulation Model (RCM) integrations are reported as a valuable dynamic downscaling approach to connect the gap between general circulation model data and projections and impact assessment applications at local to regional scales [5]; [4]. Bias is not dependent on the time during error occurred from downscaling in GCM to RCM.

MATERIALS AND METHODS

Description of Study Area

Devbhumi Dwarka district is located in Southern region of Gulf of Kutch of Gujarat state with 22°12′N latitude and 69°39′E longitude. Dwarka has its pilgrimage importance due to Dwarkadheesh Temple built in between 6^{th} and 7^{th} century. Devbhumi Dwarka district has a population of approx.750,000 lac and area is of 4,051 km^2. It is connected to the coastal area; the most of the soil is saline. The district has 4 talukas (administrative division) namely Dwarka, Bhanvad, Kalyanpur and Khambhalia consisting of 429 villages. The Dwarka district has 2.5 lakh ha area under cultivation. The district has 13 river basins among them 5 are west flowing and remaining are north flowing rivers. The climate of Dwarka has a subtropical desert/low-latitude arid hot climate. On the basis of 40 years of climatic data, the average annual rainfall is 645 mm spread over a rainy period of 29 days with rainfall limited to the months of June to September; the average maximum temperature is 31°C with a maximum of 42°C and an average minimum temperature is 15°C with a minimum of 5°C, the average annual relative humidity is 72 percent, with a maximum of 80 percent.

The Vartu basin mainly includes Vartu, Sonmati, Veradi, Sorthi and Bhanavadi rivers. Vartu river is of 53 km long. It originates from village SaiDevaliya (Taluka Bhanavad) and meets to Arabian Sea near Miyani in Porbandar district. It includes the irrigation schemes like Vartu-1, Vartu-2, Sonmati, Veradi-1, Veradi-2 and Sorthi.

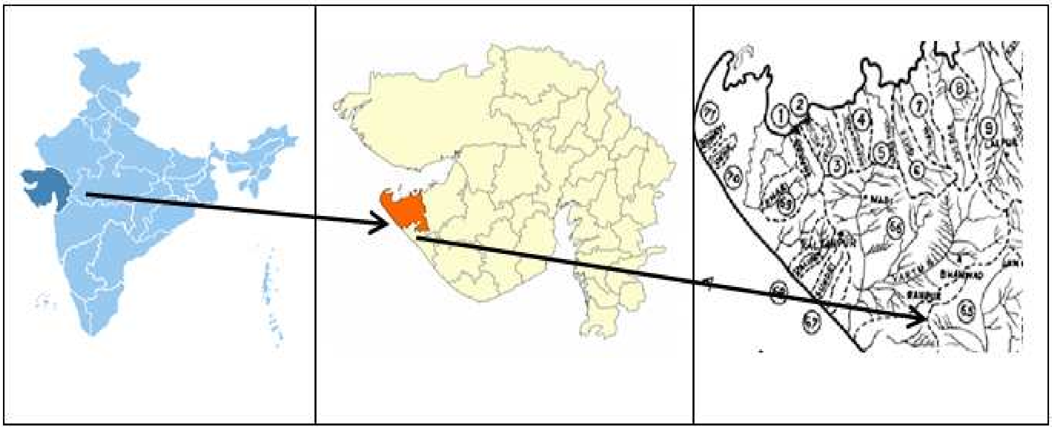

Figure 1: Location Map of Study Area

The Intergovernmental Panel on Climate Change (IPCC) has published a new set of emission scenarios in the Special Report on Emissions Scenarios (SRES) [6] to serve as a climate change impact of future climate. Among all the SRES scenarios, five emission scenarios (A1, A2, B1 B2 and A1B) are often used.

In this study, the projected changes in rainfall and temperature in the A1B is analyzed. The future weather data was obtained through CGCM232 RCM model, (Japan meteorological agency).

Bias Correction

A problem with the use of regional climate model output directly for hydrological purposes is that the computed precipitation and temperature differs systematically from the observed precipitation and temperature [1]. Bias is defined as the time independent component of the error. Bias arises because of several reasons like downscaling from GCM TO RCM. Also, the biases also influence the hydrologic processes like evapotranspiration; runoff, snow accumulation and snow melt in glacial region [10].

Distribution Mapping Method for Precipitation

The distribution mapping is toss correct the distribution function range of RCM-simulated data to agree with the observed range. This can be done by creating a transfer function [8]. The Gamma distribution [11] with shape parameter α and scale parameter β is often assumed to be suitable for distributions of precipitation events.

$$f_\gamma(x \vdots \alpha, \beta) = x^{\propto -1} \frac{1}{\beta^\alpha \Gamma(\alpha)} e^{\frac{-x}{\beta}}; x \geq 0;\ \alpha, \beta > 0 \tag{1}$$

Where, (1) $\alpha < 1$ indicates an exponentially shaped Gamma distribution having asymptotic at both axes, (2) $\alpha = 1$ characterizes an exponential distribution and (3) $\alpha > 1$ shows skewed unimodal distribution curve.

For rainfall, this procedure can be expressed mathematically in terms of the Gamma CDF ($F\gamma$) and its inverse ($F^{-1}\gamma$) as:

$$P^*contr(d) = F_\gamma^{\ -1}(F_\gamma(P_{contr}(d) \vdots \propto_{contr}, \beta_{contr,m}) \vdots \propto_{obs,m}, \beta_{obs,m})$$

$$P^*scen(d) = F_\gamma^{\ -1}(F_\gamma(P_{scen}(d) \vdots \propto_{contr}, \beta_{contr,m}) \vdots \propto_{obs,m}, \beta_{obs,m}) \tag{2}$$

For temperature analysis, the Gaussian distribution having location parameter μ and scale parameter σ is usually used [7],

$$f_N(x \vdots \mu, \sigma^2) = x^{\propto -1} \frac{1}{\sigma\sqrt{2\pi}} e^{\frac{-(x-\mu)^2}{2\sigma^2}} \tag{3}$$

The scale parameter σ determines the standard deviation.

Where, $P^*contr(d)$= corrected value of precipitation of control period,

$P\ contr(d)$= uncorrected value of precipitation of control period,

$P^*scen(d)$= corrected value of precipitation of scenario period,

$P\ scen(d)$= uncorrected value of precipitation of scenario period

$F\gamma$= Gamma CDF,

F_N= Gaussian CDF,

The mean (monthly) and Coefficient of variation of daily precipitation were computed for the bias correction methods.

RESULTS AND DISCUSSIONS

The digital data namely Map of India, Map of Gujarat, Map of Watershed, Cadastral map of river basins of Jamnagar district, Satellite images of IRS P6 of sensor LISS III and 90 m SRTM DEM were collected from BISAG, Gandhinagar. The historical hydro-metrological data (1961-2000) were collected from the State Water data Centre, Gandhinagar and Millet Research station, JAU, Jamnagar. The future weather data was obtained through CGCM232 RCM model, (Japan meteorological agency).

Analysis of the Bias Corrected Precipitation Data

Precipitation

Control Scenario (1961-2000)

The Figure 2a shows that the RCMs simulated daily precipitations were found overestimated over actual observation during May and July. However, after applying bias correction by distribution mapping method, the monthly daily mean and coefficient of variation of daily precipitation for each of 12 months was exactly matched with those of respective of observed data for the calibration line period of 1961-1990. The uncorrected RCMs precipitation had a positive (Over Estimated) bias from June and biases for the July and August months were negligible. After applying bias correction method, the monthly precipitation for the control period matched the observations (Figure 2a and Figure 2b). Figure 3 shows the Comparison of raw RCM and BCRCM daily rainfall in upper part of Vartu basin during validation period (1991-2000), with R^2 0.9138 data for bias corrected precipitation data in compared with 0.6161 of uncorrected showing statistically acceptable range [9].

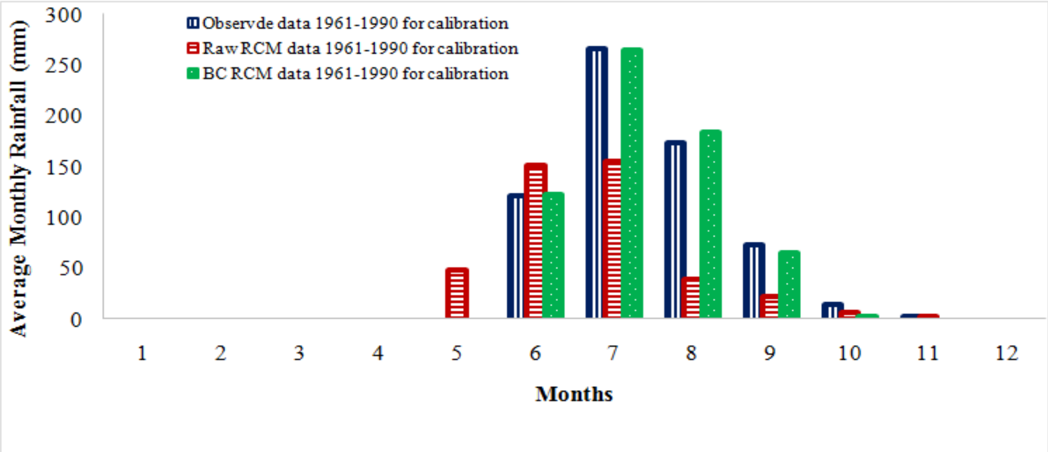

Figure 2a: Comparison of Observed, Raw RCM and Bias Corrected RCM Daily Rainfall in Upper Part of Vartu Basin during Calibration Period (1961-1990)

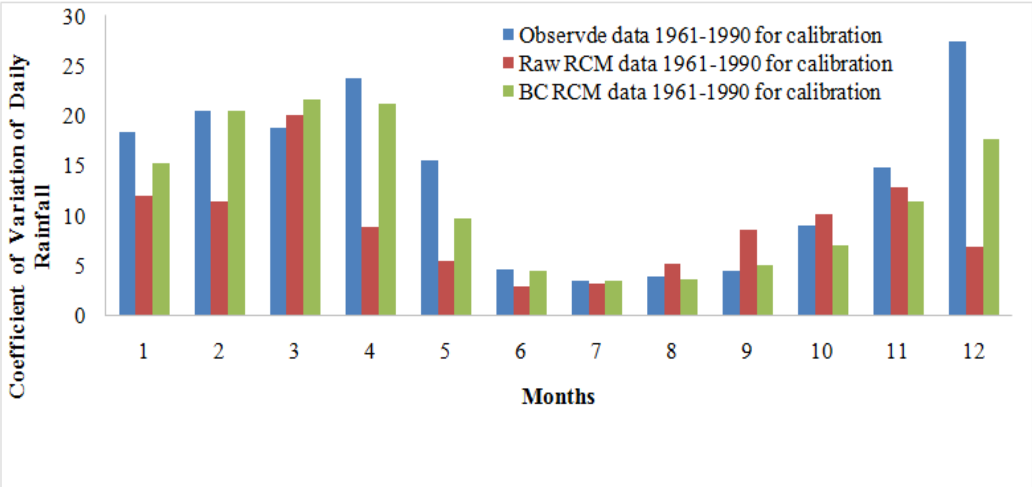

Figure 2b: Comparison of Coeffcient of Variation of Observed, Raw RCM and Bias Corrected RCM Daily Rainfall in Upper Part of Vartu Basin during Calibration Period (1961-1990)

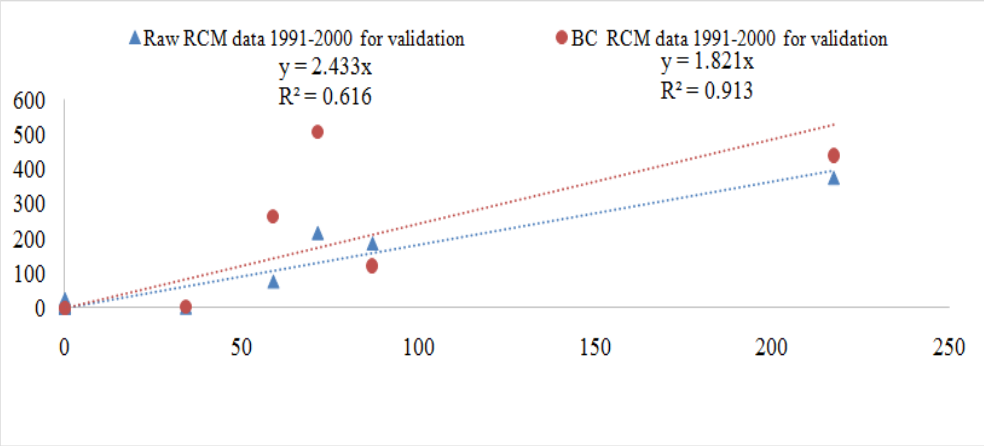

Figure 3: Comparison of Raw RCM and Bias Corrected RCM Daily Rainfall in Upper Part of Vartu Basin during Validation Period (1991-2000)

Future Scenario (2046-2064)

The Figure 4 shows that the RCMs simulated daily precipitations were found underestimated over actual observation during April, May and June. However, after applying bias correction by distribution mapping method, the monthly daily mean and coefficient of variation of daily precipitation for each of 12 months was exactly matched with those of respective of estimated data for period of 2046-2064. The uncorrected RCMs precipitation had a positive (Over Estimated) bias from June and biases for the July and August months were negligible. After applying bias correction method, the monthly precipitation for the scenario period matched with the estimated precipitation.

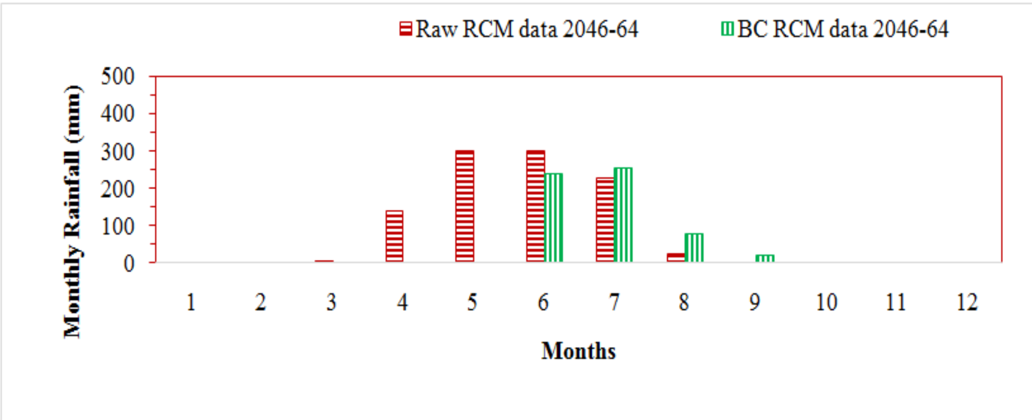

Figure 4: Comparison of Monthly Mean Rainfall of RCM and Bias Corrected RCM in Upper Part of Vartu Basin during 2046-64

Future Scenario (2081-2100)

The Figure 5 shows that the RCMs simulated daily precipitations were found underestimated over actual observation during April, May and June. However, after applying bias correction by distribution mapping method, the monthly daily mean and coefficient of variation of daily precipitation for each of 12 months was exactly matched with those of respective of observed data for period of (2081-2100). The uncorrected RCMs precipitation had a positive (Over Estimated) bias from June and biases for the July and August months were negligible. After applying bias correction method, the long-term monthly precipitation for the scenario period matched the observations.

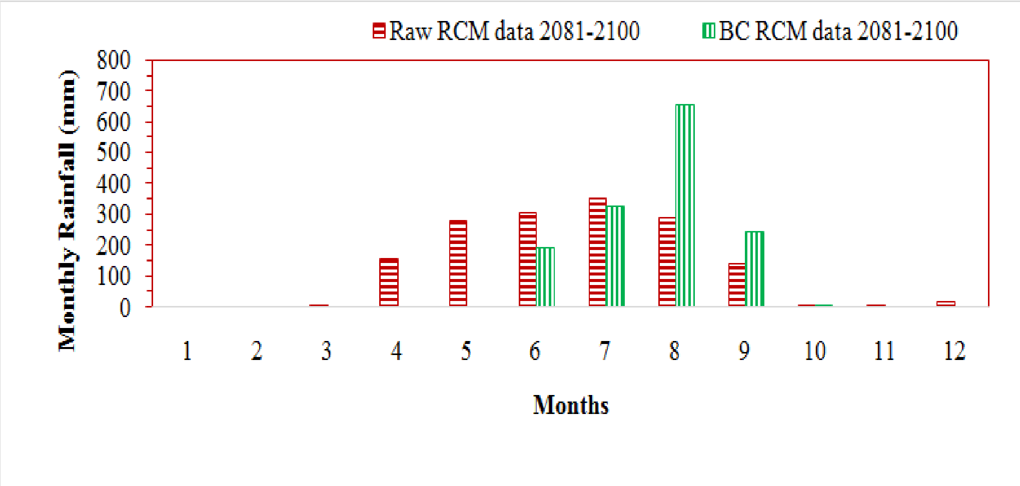

Figure 5: Comparison of Monthly Mean Rainfall of RCM and Bias Corrected RCM in Upper Part of Und Basin during 2081-2100

CONCLUSIONS

This study showed the importance for bias correction of RCM rainfall data. The bias-corrected data gives the future climate projections points toward considerable changes climatic parameters within this century and next decade. This study also gives importance of the bias correction of RCM data for the future climate change analysis.

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